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# NANOSCALE SCIENCE AND ENGINEERING (NSE) at NSF

**M.C. Roco**

Senior Advisor for Nanotechnology, NSF

Chair, Subcommittee on Nanoscience, Engineering and Technology (NSET),  
National Science and Technology Council (NSTC)

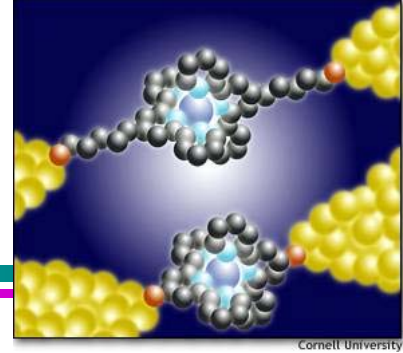
- **Nanotechnology definition**
- **The National Nanotechnology Initiative**
- **NSF contribution**
- **Steps for advancing NSE education**

**NSEE Workshop, September 29, 2003**



# Nanotechnology

Definition on [http://nano.gov/omb\\_nifty50.htm](http://nano.gov/omb_nifty50.htm) (2000)



- Working at the atomic, molecular and supramolecular levels, in the length scale of approximately 1 – 100 nm range, in order to understand and create materials, devices and systems with fundamentally new properties and functions because of their small structure
- **NNI definition encourages new contributions that were not possible before.**
  - novel phenomena, properties and functions at nanoscale, which are nonscalable outside of the nm domain
  - the ability to measure / control / manipulate matter at the nanoscale in order to change those properties and functions
  - integration along length scales, and fields of application



# Broad societal implications

(examples of societal implications;  
worldwide estimations made in 2000, NSF)

- ❑ **Knowledge base**: better comprehension of nature, life
- ❑ **New technologies and products**: ~ \$1 trillion/year by 2015  
(With input from industry US, Japan, Europe 1997-2000, access to leading experts)

Materials beyond chemistry: \$340B/y

Pharmaceuticals: \$180 B/y

Aerospace about \$70B/y

Electronics: over \$300B/y

Chemicals (catalysts): \$100B/y

Tools ~ \$22 B/y

Est. in 2000 (NSF) : about \$40B for catalysts, GMR, materials, etc.; + 25%/yr

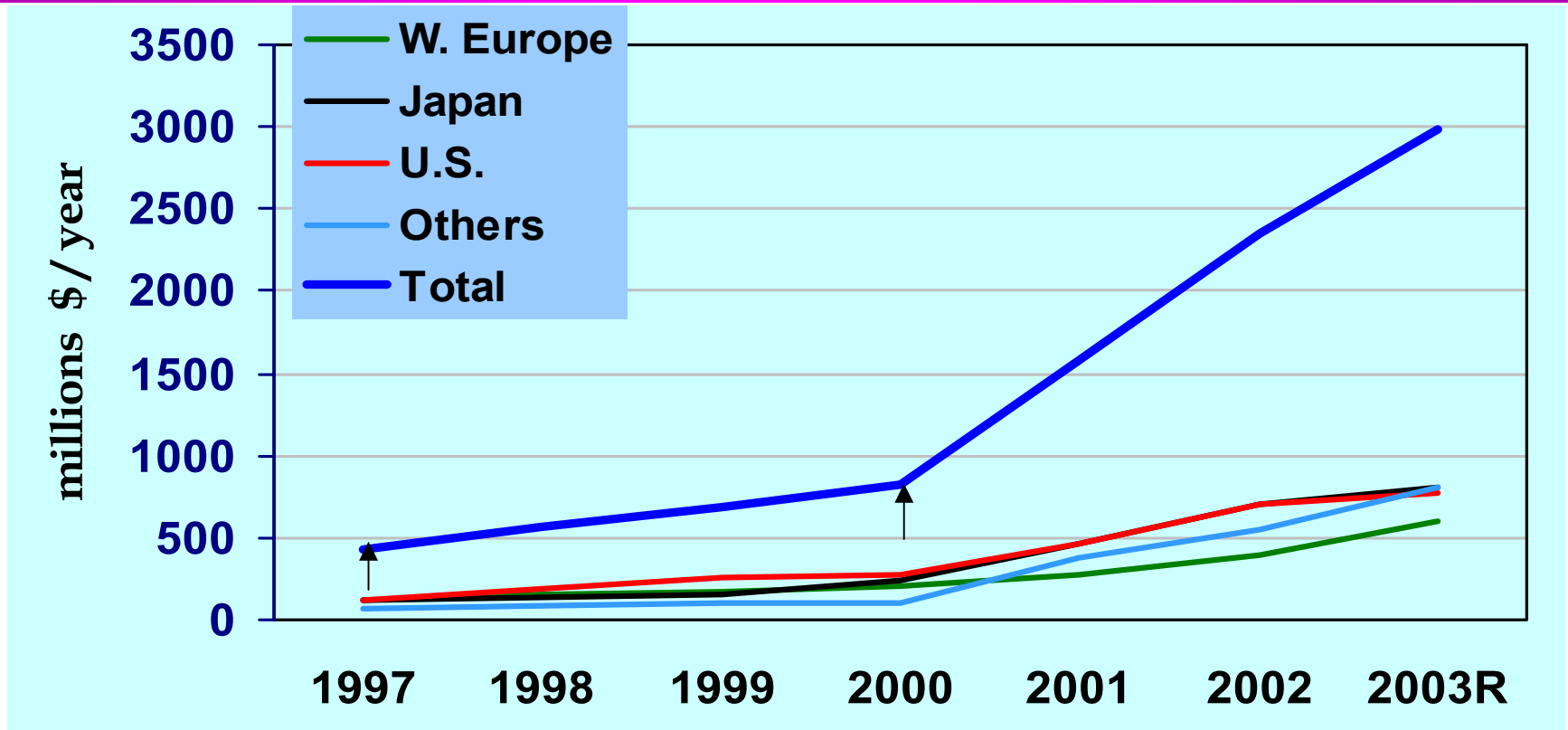
Est. in 2002 (DB) : about \$116B for materials, pharmaceuticals and chemicals

**Would require worldwide ~ 2 million nanotech workers (US ~40%)**

- ❑ **Improved healthcare**: extend life-span, its quality, physical capabilities
- ❑ **Sustainability**: agriculture, food, water, energy, materials, environment; ex:  
lighting energy reduction ~ 10% or \$100B/y

# Context – Nanotechnology in the World

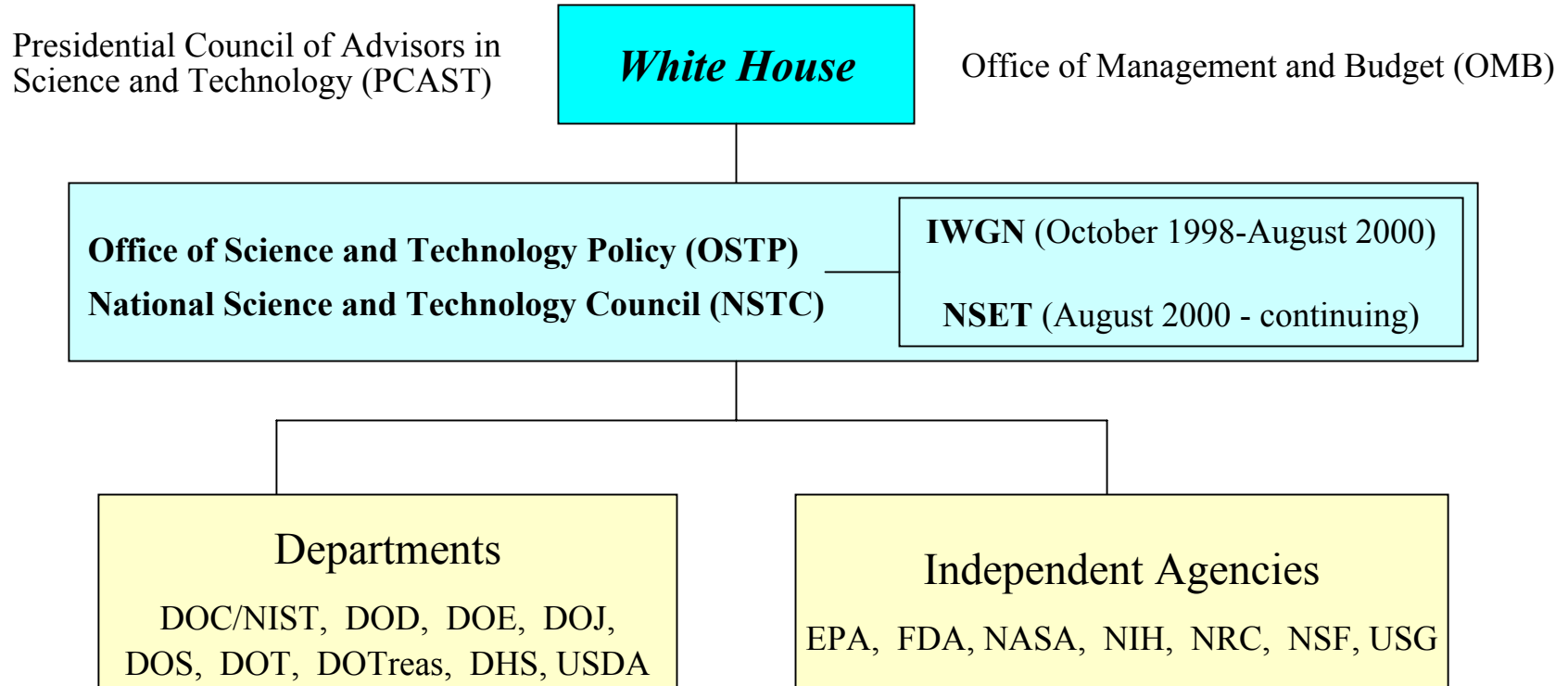
## Government investments 1977-2003



### Note:

- U.S. begins FY in October, six months in advance of EU & Japan (in March/April)
- U.S. does not have a commanding lead as it had in other S&T megatrends, such as BIO, IT, space exploration, nuclear; U.S. ~ 35% in 2000, ~ 25% in 2003

# Organizations that have prepared and contribute to the National Nanotechnology Initiative (NNI)



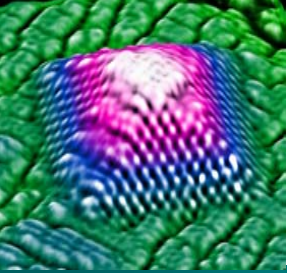
Estimation: Federal Government R&D funding      NNI (~\$700M in 02)  
Industry (private sectors)      ~ NNI funding  
State and local (universities, foundations) ~ 1/2 NNI funding

# NNI: R&D Funding by Agency

<i>Fiscal year</i> (all in million \$)	2000	2001 Enacted/actual	2002 Enacted/actual	2003	2004 Request
National Science Foundation	97	150 /150	199 /204	221	249
Department of Defense	70	110 /125	180 /224	243	222
Department of Energy	58	93 /88	91.1 /89	133	197
National Institutes of Health	32	39 /39.6	40.8 /59	65	70
NASA	5	20 /22/	35 /35	33	31
NIST	8	10 /33.4	37.6 /77	66	62
Environmental Protection Agency	-	/5.8	5 /6	5	5
Homeland Security (TSA)	-		2 /2	2	2
Department of Agriculture	-	/1.5	1.5 /0	1	10
Department of Justice	-	/1.4	1.4 /1	1.4	1.4
<b>TOTAL</b>	<b>270.0</b>	<b>422.0 /464.7</b>	<b>~ 600 /697</b>	<b>~ 770</b>	<b>~ 849</b>

Other NNI (NSET) participants are:

OSTP, NSTC, OMB, DOC, DOS, DOT, DOTreas, FDA, NRC, DHS, IC

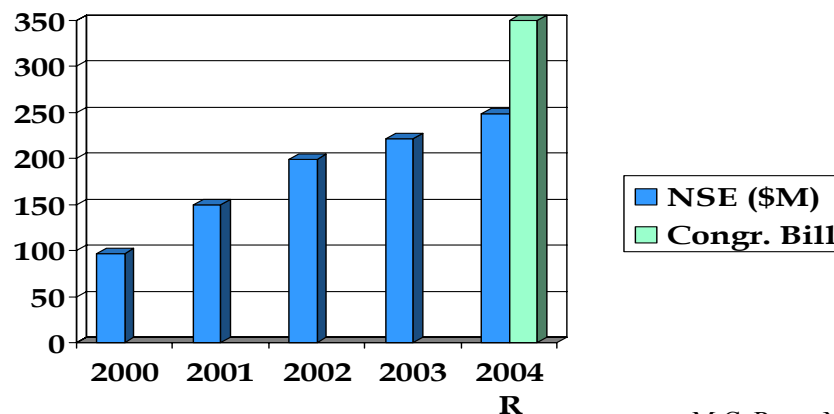


# NSF - a pioneer among Federal agencies and at the international level in Nanoscale Science and Engineering (NSE)

FY 2003: ~ 1/3 of Federal and 1/10 of World Investment

- **Seven themes:** Biotechnology, Nanostructures ‘by design’ and novel phenomena, Device and system architecture, Environmental Processes, Multiscale modeling, Nanoscale manufacturing; Societal implications and Improving human performance
- **Establishing the infrastructure:** over 1,600 active projects; 20 large centers, 2 user facilities (NNIN, NCN), multidisciplinary teams
- **Training and education** over 7,000 students and teachers

Fiscal Year	NSF	HR766
2000	\$97M	
2001	\$150M	
2002	\$199M	
2003	\$221M	
R 2004	\$249M	\$350M



# Congressional bills on nanotechnology (2004-2008)

## NNI

- *Bill passed in the House:*

*H.R.766: “Nanotechnology R&D Act of 2003”,*

- *Draft Bill pending in the Senate*

*189 “21<sup>st</sup> Century Nanotechnology R&D Act”  
5-year “National Nanotechnology Program”*

## NSE: Authorized budgets for NSF

- FY 2004 - \$350 million
- FY 2005 - \$385 million
- FY 2006 - \$424 million



Defining the vision

# National Nanotechnology Initiative

([www.nano.gov](http://www.nano.gov) and [www.nsf.gov/nano](http://www.nsf.gov/nano))



“Review of NNI” by NRC for WH/OSTP (June 2002)

Topical reports for NSET & various agencies by Summer 2004

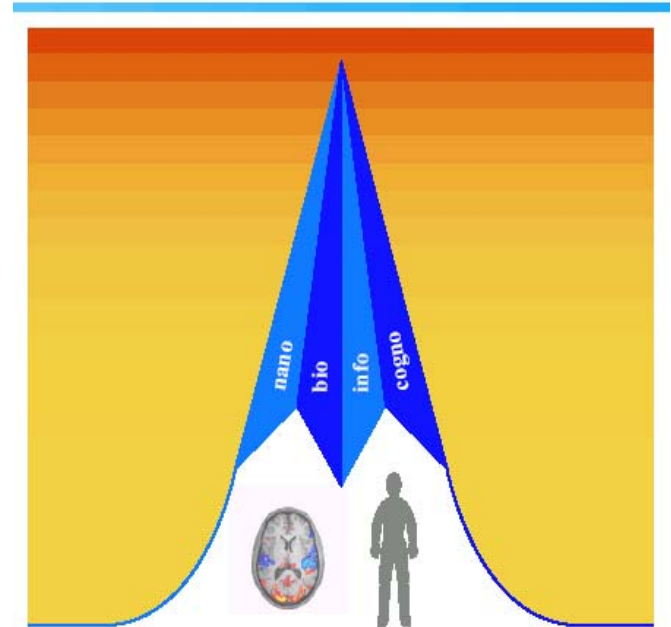
Revisit the vision Spring 2004: **Nanotechnology Research Directions II**

# Integrating science and technology from the nanoscale

- **Broad and timely opportunity**

- Understanding unity in nature, science and technology integration from the nanoscale
- Powerful transforming tools (NBIC: nano-bio-info-cogno) developing at confluence of disciplines
- Improvement of individual and group human performance becomes possible
- Reversing the “pyramid” of learning, to begin with basic concepts of unity in nature

- **NBIC - agents of accelerated, synergistic change in society**



CONVERGING TECHNOLOGIES  
FOR IMPROVING HUMAN PERFORMANCE

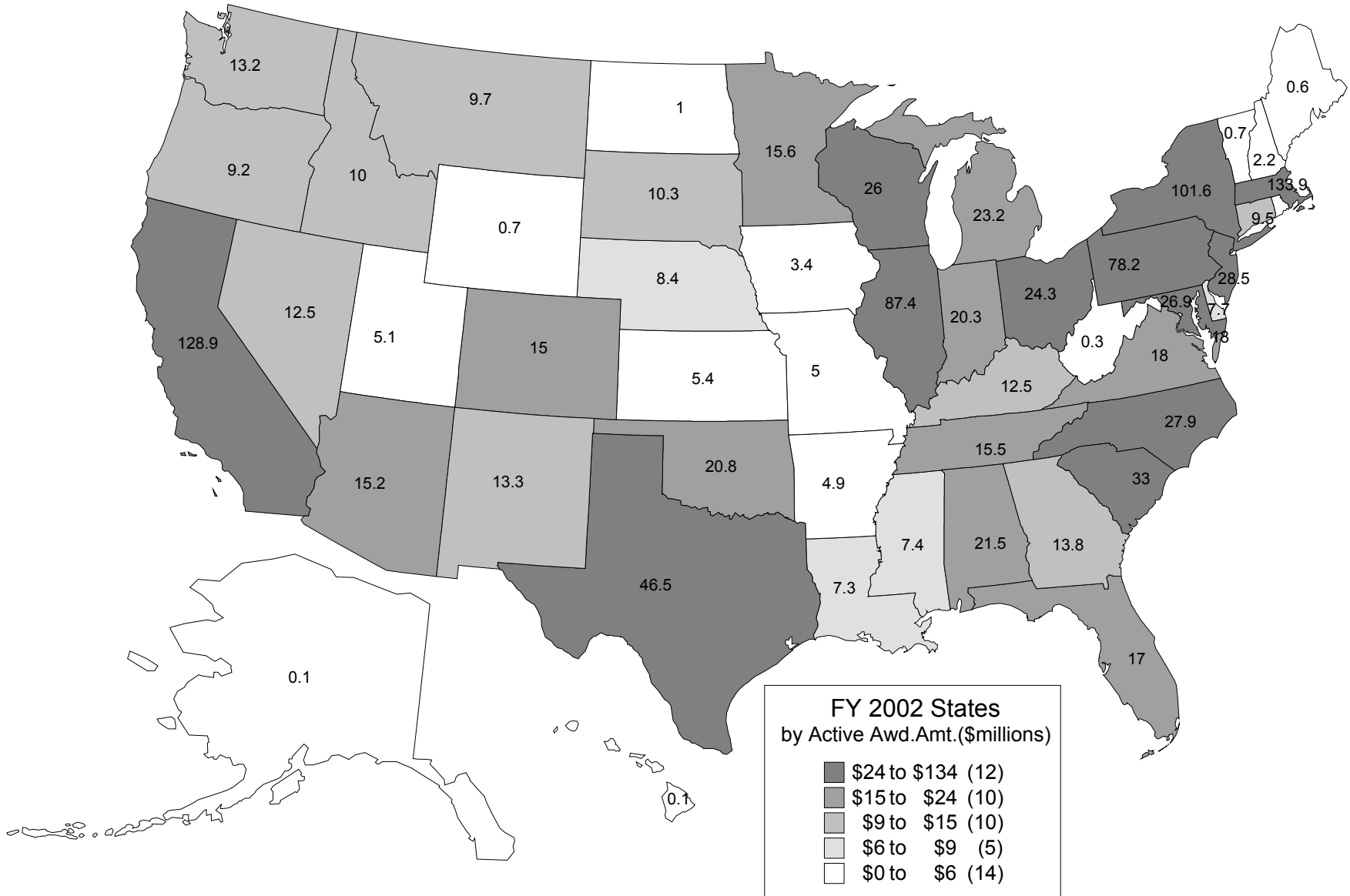
June 2002



(December 2001)

Online [www.nsf.gov/nano](http://www.nsf.gov/nano),  
also Kluwer Academic Publ

# Geographical distribution





# Education and Training

- Towards systemic changes:  
foundation from micro to nano -

- **Integrated Research and Education - Make Every Lab a Place of Learning** (over 7,000 trained per year)
- **Curriculum development**  
New courses, 10 IGERT, Nanotech Undergrad Education
- **Education and outreach programs**  
from K-12 to G; includes NSEE; museums; parts centers  
(see Int. J. of Eng. Education, Aug.2002, Vol. 8, for an overview of programs)
- **International education opportunities**  
young researchers to Japan and Europe; REU sites;  
attend courses abroad; PASI - Latin America, NSF-E.C.;  
bi-lateral workshops and exchanges

# Nanotechnology Undergraduate Education (NUE)

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**New component of the 2003 NSF Nanoscale Science and Engineering (NSF 02-148) program is focused on:**

- Introductory undergraduate courses presented through the development of text, software, laboratory and demonstration experiments, and web-based resources;
- Development and dissemination of new teaching modules for nanoscale science and engineering that can be used in existing undergraduate courses, particularly during first and second year studies.

**33 awards in FY 2003**

**Reviewed by the NSF workshop on September 11-12, 2002 at NSF ([www.nanofab.psu.edu/education/nsf-nue-program.htm](http://www.nanofab.psu.edu/education/nsf-nue-program.htm))**

# Nanoscale Science and Engineering support at NSF in FY 2004

The budget allocation expected between \$249M (NSF Request) and \$350M (Congress bills)

- Program solicitations (about \$91M, about 1/3)
  - Nanoscale Science and Engineering \$79M, NSF 03-043, by 10/22/03
  - Nanoscale Science and Engineering Education \$12M, NSF 03-044
- Support in the core program (about 2/3)  
with focus on single investigator & other core
  - Various research and education programs in all directorates
  - Interdisciplinary fellowships; STC, MRSEC and ERC centers
  - Instrumentation (REG, MRI); Collaboration industry (GOALI, PFI)
  - Network for Computational Nanotechnology
  - National Nanotechnology Infrastructure Network
- **SBIR/STTR** (additional ~ \$10M)